PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Retrievable Drilling Apparatus for Bore Holes

I, ARCHER WILLIAM KAMMERER, a citizen of the United States of America, of 800 North Raymond Avenue, Fullerton, County of Orange, State of California, United States of America, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the rotary drilling of well bores, and more particularly to retrievable rotary drilling bits for drilling the well bores.

Oil, gas, water, sulphur and similar well bores have heretofore been drilled by securing a bit to the lower end of a string of drill pipe and lowering such pipe in the hole to its bottom position, the drill bit then being rotated to continue the formation of the well bore. As each bit becomes dull the drill pipe is removed from the well bore and another bit attached to it and the string of pipe re-lowered in the well bore. After the desired depth of hole has been produced, the drill pipe is removed and a string of casing or the like lowered in the hole, which may then be cemented in place.

The necessity for frequency changes of the drill bits is a time consuming and costly operation. Potential damage to the well bore is also present due to pressures and the like developed in the drilling and, caused by the raising and lowering of the string of drill pipe. There is also the danger of being unable to lower the casing in the drilled hole to the required depth, or in damaging the well formation during lowering of the casing.

An object of the invention is to provide an improved drilling apparatus which avoids the necessity for repeated raising and lowering of the drilling string to change the drill bit, the apparatus being capable of being lowered and removed through a string of pipe, which will form the ultimate casing for the well bore, and of being readily coupled to the lower portion of the pipe, which is then rotated to effect drilling of the hole, and of being released from the pipe and retrieved through its bore after the bit becomes dull or is to be retrieved for any other reason.

Another object of the invention is to provide a retrievable drill bit adapted to be lowered through a string of pipe to its lower portion, or shoe, and of being rotationally coupled thereto, the drilling bit having cutters expandable outwardly beyond the outside diameter of the pipe, the cutters being retained in their expanded positions when the bit is elevated from the bottom of the hole.

A further object of the invention is to provide a retrievable drilling bit having expandable cutters and capable of being lowered through a string of pipe to be rotationally coupled to its lower portion, the bit permitting circulating fluid at high volumetric rates to be pumped through it, ensuring thorough removal of the cuttings from the drilling region, cleaning of the bit, and cooling and lubrication of the bit.

According to the invention, I provide a retrievable drilling bit adapted to be lowered within, and coupled to, the lower portion of a string of pipe disposed in a well bore, said bit comprising a body movable longitudinally through the pipe, initially retracted cutter means mounted on said body for movement laterally outwardly of said body, means to engage a lower portion of the pipe so to locate the bit in the pipe so that said cutter means projects below the lower end of the pipe and means for expanding said cutter means laterally outwardly of the body for drilling a bore hole having a diameter greater than that of the outside diameter of the pipe, the cutter means, when expanded, being directly coupled to the pipe so that torque and downward longitu-

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dinal force applied to the pipe is transmitted to the cutter means.

Preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 is a longitudinal section, parts being shown in side elevation, of a drilling bit within and at the lower portion of a string of casing or similar pipe, the apparatus being in its initial retracted position,

Figure 2 is a view similar to Fig. 1, illustrating the drilling bit with its cutters in their expanded position and coupled to the string of pipe.

Figure 3 is a longitudinal section of the upper portion of the apparatus, showing a latch device in the position it occupies with the bit in the position shown in Fig. 2,

Figure 4 is a section on the line 4—4 of Fig. 1,

Figure 5 is a section on the line 5—5 of Fig. 3,

Figure 6 is a section on the line 6—6 of Fig. 3,

Figure 7 is a fragmentary side elevational view of one of the cutter devices in expanded position and coupled to the lower portion of the string of drill pipe or casing.

Figures 8 and 9 are views corresponding respectively with Figs. 1 and 2 and showing another construction according to the invention.

As disclosed in Figs. 1 to 7, inclusive, the apparatus comprises a lower or shoe portion 10 of a string of well casing A, or similar pipe, which extends to the top of the well bore B being drilled. This string of casing is rotated to transmit the drilling torque (the drilling weight also being suitably applied) to a retrievable drilling bit C adapted to be coupled to the shoe portion 10 of the casing string. The drilling bit is movable down through the casing string A, which is already disposed in the portion of the well bore B previously drilled, and is releasably coupled to the shoe portion of the casing, after which the drilling of the well bore can proceed by rotating the string of casing and moving it progressively downwardly as the hole is produced, to move the cutters 11 of the bit against the bore formation. During the rotary drilling operation, drilling mud, or the like, is pumped down through the interior of the casing string A and discharges from, and around, the bit C to carry the cuttings upwardly and around the string of casing to the top of the bore. When a bit becomes dull, it is uncoupled from the casing string and withdrawn through the casing interior to the top of the bore, whereupon the same drill bit with new cutters, or another drill bit, is lowered through the casing string and coupled to shoe portion 10. When the new cutters become dull, the drill bit is again withdrawn through the interior of the casing string and the cutters replaced. The foregoing action is repeated as often as necessary to drill the bore B to the desired depth. It is to be noted that the casing string need never be withdrawn from the well bore during drilling of the hole. It is only necessary to add additional sections at the top of the well bore as drilling proceeds. In fact, after the hole has been drilled to the desired depth, the casing string can remain therein to be cemented in place, if desired, in substantially the same manner as casing strings are ordinarily cemented in well bores.

The drilling bit C comprises an elongated body 12 having a lower, threaded box 13 to which a pilot bit 14 can be secured, as by screw threading the upper, pin end 15 into the box. Above box 13 the bit has a transverse and elongated slot 16 in which a plurality, such as a pair, of cutter devices are mounted. Cutter supporting members 17 are disposed in the elongated slot 16, being pivoted on hinge pins 18 extending across the slot and suitably secured to the body 12. Each member 17 carries a cutter 11, such as a conical toothed cutter, which, when expanded outwardly in the manner described hereinbelow, will drill the bore B to a diameter substantially greater than the outside diameter of the casing string A and enlarge the diameter of the pilot hole D which is drilled by the bit 14.

The cutters 11 normally occupy the position disclosed in Fig. 1 in which they are retracted fully within the confines of the body 12. They are expanded outwardly of the body and are thereby coupled to the casing A by downward movement of a mandrel 19 within the body 12. As shown, the mandrel comprises an upper, piston 20 slidable within a cylinder 21 in the body, leakage of fluid between the piston and cylinder being prevented by a suitable seal 22, such as a rubber or rubber-like O-ring, received in a groove 23 in the body, the O-ring slidably and sealingly engaging the periphery of the piston. Secured to the piston 20 and depending therefrom is a tubular member 24 of the mandrel, the lower part of which is slidable through a guide 25 extending across the slot 16 and attached to the body 12. The upper portion 26 of member 24 is pivoted within the piston 20, its upper end engaging a downwardly-facing shoulder 27. Downward movement of member 24 with respect to the piston 20 is prevented by a row of balls 28 which engage a downwardly facing raceway 29 on the tubular member and which are received within an internal raceway 30 in the piston. The balls 28 are insertable through a threaded radial hole 31 in the piston which is closed by threaded plug 32 (Figs. 1 and 2). Leakage of fluid between the piston and tubular member is prevented by a seal 33.

When the piston 20 and tubular member 24 move downwardly, an expander 34

mounted on, and fixed to, the tubular member engages inclined surfaces 35 on the support members 17 thereby to pivot the latter and the cutters 11 about hinge pins 18 so that the cutters 11 are moved outwardly (Fig. 2). When the cutters have been shifted outwardly to their maximum extent, holding surfaces 36 on the expander 34 are positioned within holding surfaces 37 on the members 17 to prevent inadvertent retraction of the members 17 (and cutters 11) from their expanded position. The piston 20 and tubular member 24 are shiftable downwardly to the maximum extent determined by engagement of expander 34 with the guide 25.

The mandrel 19 is normally urged downwardly to expand member 17 and the cutters 11 by a spring 100. The spring 100 is of the tension type and surrounds member 24, the upper end of the spring being fastened to the piston 20 (the uppermost coils 101 of the spring being received within grooves 102 of the piston 20) and the lower end of the spring being secured to the body 12 (lowermost coils 103 being received within grooves 104 in the body 12).

While the spring 100 tends to move the mandrel 19 downwardly for the purpose indicated outward expansion of members 17 and cutters 11 to any significant extent is prevented during lowering of the drilling bit C through the casing string A by the outer surfaces 105 of members 17 which slide along the wall of the casing A.

The cutters 11 may also be urged to their expanded position, after the drilling bit has been coupled to the casing A, by fluid pressure developed in the body 12 of the tool above the piston 20. Such fluid pressure is obtained from drilling mud, or similar fluid, which is pumped through the casing string A, the mud under pressure entering the upper end of the body 12 and passing through inlet ports 106 in the mandrel above the piston 20 and thence into a central passage 107 in member 24. The fluid under pressure flows through a nozzle 108 at the lower end of member 24 and is discharged into the slot 16. Because of a throttling action provided by the inlet ports 106, or by the nozzle 108, a pressure is built up in the body 12 above the piston 20 which will urge the latter downwardly and with it the mandrel 19 and the tubular member 24 thereby to effect outward expansion of members 17 and the cutters 11.

Once the cutters 11 have been expanded outwardly they are releasably locked in expanded position. A carrier member 43 forms an upward extension of the mandrel 19, the lower end 44 entering the upper portion 45 of the mandrel and being suitably secured thereto, e.g. by a welded joint 46. This carrier extends upwardly through a spider or latch sleeve 47 mounted in the upper end of the body 12, having inwardly directed ribs 48, circumferentially spaced from one another and which are engageable with the periphery of the carrier. The latch sleeve 47 is held within the body by a split ring 49 disposed within a groove 50 in the body, downward movement of the spider 47 within body 12 being prevented by engagement of flange 51 and shoulder 52.

The carrier 43 has an elongated slot 53 (Fig. 3) extending therethrough receiving a latch member 54 pivotally mounted on a hinge pin 55 extending across the carrier slot and suitably secured thereto, as by welding. The latch 54 also extends within a slot 56 in a retrieving plunger 57 movable longitudinally in a bore 58 in the latch carrier 43, downward movement of the plunger within the carrier being limited by engagement of a flange 59 with the upper end of the carrier. The latch 54 is urged outwardly of the carrier 43 by a compression spring 60 (one end of which engages the inner wall of the carrier 43 and the other end of which engages an upwardly extending lug 61 on the latch) to move a latch finger 62 outwardly of slot 53 and under one of the ribs 48 of the spider 47. The slot 53 and the latch 54 are aligned with one of the ribs 48 by screws 63 secured to the carrier 43 on opposite sides of another rib 48 (Fig. 5).

During the movement of the drilling bit through the well casing the mandrel 19 and the carrier 43 attached thereto are disposed in an upward position within the body 12 (Fig. 1), despite spring 100 urging the mandrel downwardly within the body. In this position, the latch finger 62 is inwardly of the carrier 43 and in engagement with the inner surface of one of the spider ribs 48. However, when the mandrel 19 is moved downwardly by the spring 100, or by the pressure of the fluid pumped down through the casing string A, or both, the carrier 43 and latch 54 move downwardly with the mandrel until the latch finger is below a rib 48. The spring 60 then swings the latch 54 outwardly to bring latch finger 62 under the rib (Fig. 3). The mandrel 19 cannot then be raised inadvertently within the body 12.

When the latch 54 is in its latching position, such as shown in Fig. 3, the hinge pin 55 in the latch is relieved of the latching force. The hole 65 in the latch is elongated, permitting a slight longitudinal movement of the latch within the carrier slot 53 and across the pin. It is arranged that when the upper end of the finger 62 engages the lower end of the rib 48, the lower end 66 of the finger will engage the surface 67 of the slot 53. It is evident from Fig. 3 that the hinge pin 55 is relieved of the thrust transmitted through the latch 54 between the carrier 43 and the spider 47.

The latch 54 is released whenever the cutters 11 are to be retracted by moving the retracting plunger 57 upwardly. This plunger

has a retrieving pin 68 secured thereto, which is slidable in opposed longitudinal slots 69 in the carrier, and which pass through an opening 70 in the latch. Initially, the retracting pin 68 is in a lower position within the slots 69 and the opening 70 (see Fig. 3). In this position, the finger 62 is free to be moved outwardly by spring 60 when mandrel 19 is lowered within the body 12. In this position the left side 71 of the opening 70, as seen in Fig. 3, is inclined in an upward and outward direction. Accordingly, when plunger 57 is raised within the carrier 43, the retracting pin 68 engages the inclined side 71 of the latch 54 and withdraws the latch against the force of spring 60 completely within the carrier 43, thereby releasing the finger 62 from the rib 48 and allowing the mandrel 19 to move upwardly within the body 12 of the tool. Elevation of the retracting plunger 57 to release the latch 54 will bring pin 68 in contact with the carrier 43 at the upper end of the slots 69, whereupon the upward force on the retracting plunger 57 will be transmitted through the retracting pin 68 to the carrier 43, which is actually a part of the mandrel 19. The mandrel is then forcibly moved upwardly within the body 12 of the tool against the tension force of the spring 100, the expander 34 being moved to above the surfaces 35 on members 17, permitting the latter and the cutters 11 to move inwardly to their retracted position. If the members 17 and the cutters 11 do not move inwardly then the upward movement of the mandrel 19 will bring a flange or shoulder 75 on the mandrel to engage arms 76 on the members 17 and thereby to move such arms upwardly so that the members 17 and the cutters 11 are forced to pivot on pins 18 and moved inwardly within the slot 16. Once the members 17 are substantially within the slot 16, the tension spring 100 is prevented from moving the cutters 11 outwardly since members 17 engage the inner wall of the casing string A.

The drilling bit C is adapted to move downwardly through the entire casing string A to the shoe portion 10 of the latter. Its downward movement is limited by engagement of a stop ring or thrust collar 77 on the upper portion of the body 12 (Figs. 1 and 3) with a shoulder 78 in the casing. When the stop ring 77 engages shoulder 78, the pilot bit 14 is substantially below the lower end of the shoe portion 10. The lower portion 17a of each member 17 is inwardly of a slotted coupling portion 79 at the lower end of the shoe, each cutter 11 being below the lower end 80 of the shoe. The members 17 are expandable outwardly to within slots 81 in the portion 79 of the shoe. Each slot is sufficiently wide to accommodate a cutter-supporting member 17, and each slot has a driving face 82 (Fig. 4) adapted to engage the side of a member 17 to rotate the latter. The upper end 83 of each slot (Fig. 7) constitutes a thrust shoulder or surface adapted to engage a shoulder or stop 84 (Fig. 2) on the member 17.

Outward movement of members 17 is limited by engagement of a surface 85 on each member with the inner surface 86 of the shoe portion. The surfaces 36 on the expander 34 coact with surfaces 37 on the members 17 to prevent inward movement of the latter.

The driving face 82, which will engage face 87 on a member 17, is preferably flat so that there is a substantial surface engagement between the driving face and the side face of the member. The opposed side 88 of each slot 81 is curved (Fig. 4), the curve running from the inner surface 86 of the shoe portion 10 toward its outer surface and in a direction toward the face 82. The curved guide surface 88 will be engaged by the outer surface 105 or corner 89 of member 17 when it is expanded outwardly by the mandrel 19 as the latter moves downwardly within the body 12, in the event that the members 17 are not aligned with a pair of diametrically opposed slots 81. The expanding force will cause the members 17 to slide along the curved guide surfaces 88 as they move to their outward position, until they move fully within the slots 81. Such arcuate movement of the members 17 is accompanied by arcuate movement of the body 12 of the tool. To facilitate this movement, a roller bearing 90 is provided between the stop ring 77 and the body 12. As shown (Fig. 3), a set of balls 91 is mounted in an external race 92 in the upper portion of the body 12, and these balls engage a companion upwardly facing race 93 in the thrust ring 77. The balls 91 can be inserted between the raceways through a radial hole 94 in the body 12 of the tool, which is then closed by threaded plug 95.

In the event that the members 17 and cutters 11 (while being expanded outwardly) are misaligned with the slots 81, they might engage the curved corner 98 (Fig. 4) which is located between a driving face 82 in one slot and the guide surface 88 of an adjoining slot. Because of the curved exterior 105 of each member 17, if it does not slide in a clockwise direction, as seen in Fig. 4, along the curved guide surface 88 into alignment with all of the slots 81, it will slide along the corner 98 in a counter-clockwise direction into alignment with another of the slots 81, whereupon the members 17 are expandable fully outwardly until stop surface 85 is in engagement with the internal surface 86 of the shoe portion 10, and with its shoulder 84 under, and adjacent to the downwardly directed thrust surface or shoulder 83 on the shoe portion. When the cutters 11 are locked in their expanded position by the latch 54, the cutters cannot move upwardly of the shoe portion 10, which is also true of the body 12 of the tool; while the body of the tool itself cannot move down-

wardly of the shoe portion 10, by virtue of the engagement of the stop ring 77 with the shoulder 78.

The pilot bit 14 will drill a pilot hole D, which is less in diameter than the outside diameter of the shoe portion 10 (Fig. 2), whereas the cutters 11, when expanded outwardly, will form and operate upon a transverse shoulder E located between the wall of the pilot hole D and the enlarged diameter of the bore B, which is substantially greater than the outside diameter of the casing string A. Drilling mud can now be pumped down through the casing string and may be prevented from passing around the exterior of the body 12 near its upper portion because of the provision of suitable side seal rings 99, such as rubber O-rings, disposed in peripheral grooves 110 in the body and sealingly engaging the inner surface 86 of the casing below its shoulder 78 (Fig. 1). The fluid will flow through the passages 111 (Fig. 5) between the spider ribs 48 and the carrier 43, passing into the body 12 and downwardly around the carrier 43, some of the fluid continuing on through the inlet ports 106 and passage 107 to discharge from the nozzle 108. Such fluid may discharge at a considerable velocity, a substantial portion of it flowing into a fluid guide 112 in the body of the tool at the lower end of the slot 16, which is suitably welded to the body. The fluid passes through a passage 113 in the body 12 and into a drill bit passage 114, discharging through the drill bit nozzles 115 to remove the cuttings from the drilling region of the pilot bit 14 and flushing them upwardly around the exterior of the drilling bit C and the casing A back to the top of the hole. Some of the drilling fluid discharging from the nozzle 108, as well as the drilling fluid discharging rom the nozzles 115, will pass around the cutters 11 and the transverse shoulder E on which the cutters are operating, carrying the cuttings upwardly around the exterior of the casing shoe 10 and the casing string A back to the top of the well bore B.

A large quantity of the drilling mud or other drilling fluid will also pass around the exterior of the body 12. Part of such fluid flowing through the passages 111 between the spider ribs 48 and the carrier 43, and into the body 12, will pass outwardly through side ports 116 to the exterior of the body, flowing downwardly through the annular space 117 between the exterior of the body 12 and the inner surface 86 of the casing shoe and discharging from the lower end of the casing A. This fluid will also act in large measure directly upon the cutters 11 and the transverse shoulder E on which such cutters are operating, carrying the cuttings produced by the cutters 11 upwardly around the exterior of the shoe portion 10 and the casing string A to the top of the well bore B. The annular passage area between the body 12 of the tool and the inner wall 86 of the shoe portion 10 can be quite large, allowing relatively large volumes of drilling mud to pass therethrough for the purpose of keeping the cutters 11 and the drilling region E clean of the cuttings, as well as appropriately cooling and lubricating the parts.

In the use of the apparatus illustrated in Figs. 1 to 7, inclusive, the mandrel 19 is elevated in the body 12 of the tool against the force of the tension spring 100 so that the cutters 11 and the cutter supporting members 17 can be placed in their retracted position. The drilling bit C is inserted in the casing string and will either gravitate through the drilling mud therewithin or can be forced down through the casing string until the thrust ring 77 engages the shoulder 78. In this position the pilot bit 14 will be disposed below the lower end 80 of the shoe portion, which is also true of the cutters 11 and part of the members 17. The spring 100 then urges the mandrel 19 in a downward direction, causing the expander 34 to engage the surfaces 38 and swing the members 17 and cutters 11 outwardly. If the cutter supporting members 17 are misaligned with a pair of opposed slots 81, they will engage either the curved guide surfaces 88 or the corners 98 of the shoe, to be shifted in one direction or another into alignment with the opposed slots 81, whereupon they will move outwardly within the slots to the extent determined by engagement of the upper exterior surfaces 85 of the members 17 with the inner surface 86 of the shoe portion 10, at which time the thrust shoulders 84 on the cutter supporting members 17 are disposed under and closely adjacent to, if not against, the thrust shoulders 83 on the shoe portion. The expander 34 will also have moved downwardly to its maximum position, in which its holding surfaces 36 are disposed behind the surfaces 37 on the members 17. When this occurs, the latch 54 will have been shifted outwardly by the spring 60 to dispose its finger 62 under a spider rib 48, thereby locking the mandrel 19 in a downward position within the tool body 12, assuring that the members 17 and cutters 11 will be held in their outward position.

If difficulty is encountered in securing the full expansion of the cutters 11 and members 17 under the influence of the tension spring 100, the pumping of drilling mud or the like downwardly through the casing string A will cause its fluid pressure to act upon the piston 20, urging the mandrel 19 downwardly and thereby providing a hydraulic force to supplement the spring force.

The casing string A is rotated at the proper speed and the desired drilling weight imposed through the casing string on to the shoulders 84 of the members 17, such drilling weight being transmitted from the supporting members through the cutters 11 to the shoulder E.

At the same time drilling weight is being transmitted to the pilot drill bit 14 to ensure the production of the pilot hole D. Drilling mud is pumped down through the casing string while it is being rotated, the drilling mud discharging through the side ports 116 and the annular space 117 between the body and the shoe portion, and also through the nozzle 108, the combined streams of drilling mud removing the cuttings from the region of the expansible cutters 11, some of the fluid passing down through the pilot bit 14 to remove the cuttings in the pilot hole D. The cuttings from the different regions of the well bore are flushed upwardly around the exterior of the casing A to the top of the hole B.

Drilling can proceed until the cutters 11 have been worn, after which the drill bit C is removed without removing the casing string A from the hole. Such action can occur by lowering a suitable overshot (not shown) on a sand line (not shown) through the casing string A, the overshot coupling itself to the head 120 of the retrieving plunger 57, which can then be pulled upwardly. Such upward pull will cause the retrieving pin 68 to release the latch 54 from the spider rib 48, after which the mandrel 19 is pulled upwardly within the body 12 against the force of the tension spring 100 to elevate the expander 34 above the surfaces 35 of the members 17. The members 17 will now move inwardly. If need be, to ensure such inward movement, the casing string A may be elevated a slight distance to raise the cutters 11 from the shoulder E. Upward movement of the sand line will result in upward movement of the entire drilling bit C through the casing A to the top of the bore. The tension spring 100 does no more than urge the outer surfaces 105 of the members 17 against the inner wall of the casing string. However, there is comparatively little frictional resistance to sliding offered by such contact with the wall of the pipe, so that there is little resistance to upward movement of the drill bit C through the casing A.

Another drill bit C can then be lowered in the well casing A, or the worn cutter portions 11, 14 of the removed drill bit replaced with new cutter portions and again inserted and lowered in the casing, with its cutters 11 in retracted position until the thrust ring 77 engages the casing shoulder 78. The spring 100 will again shift the mandrel 19 downwardly within the body to expand the cutter devices 17, 11 outwardly, until they are securely locked to, and within, the shoe portion 10, in the manner shown in Fig. 2, the latch 54 preventing inadvertent upward removal of the mandrel 19 within the body 12 of the tool. For that matter, inadvertent upward removal of the mandrel is also prevented by the continuing tension force exerted by the spring 100.

By the expedient of coupling and releasing a drilling bit C from the well casing A, the entire well bore B can be drilled without the necessity for removing the casing string from the well bore. After the bore B has been drilled to the desired depth, the last used drill bit need merely be removed from the casing string to the top of the hole, whereupon the casing string A can, if desired, be cemented in the bore hole.

In the construction of Figs. 8 and 9, the drilling bit is essentially the same as in the embodiment previously described, with the exception that the mandrel 19*a* is not positively latched in its downward position within the body 12. Instead, reliance is placed upon the tension spring 100 to hold the mandrel in its downward position, with the cutters 11 and cutter supporting members 17 locked in their outward expanded position. In lieu of the latching device, the upper portion of the mandrel has a retrieving head 120*a* which is adapted to be engaged by a suitable overshot (not shown) whenever the apparatus is to be retrieved from the well casing.

The cutters 11 and members 17 are placed in their retracted position with the spring 100 under tension and are inserted in the well casing A. The assembly is lowered through the casing until the stop ring 77 engages the casing shoulder 78. During its descent through the well casing, the cutter supporting arms 17 merely slide along the wall of the well casing. After the stop ring has engaged the shoulder, the spring 100 will urge the mandrel 19*a* downwardly to expand the cutters 11 outwardly. If need be, the casing A can be rotated to secure sufficient relative arcuate movement between the shoe portion 10 and the body 12 of the tool, such that the cutter-supporting members 17 will be aligned with the slots 81, allowing the expander 34 to move the members 17 outwardly into the slots 81, until the fully expanded position shown in Fig. 9 is achieved.

Drilling can now proceed with the casing A being rotated and the drilling weight and torque being transferred directly from the shoe portion 10 to the members 17 and the cutters 11, which then roll around the formation shoulder E, while the pilot bit 14 engages the bottom of the pilot hole D. Drilling mud is pumped down through the casing, passing into the upper end of the body 12 and then flowing downwardly through the mandrel ports 106 to the central passage 107 of the latter and discharging through the nozzle 108, as in the arrangement of Figs. 1 to 7. Similarly, the drilling mud passes out through the body side ports 116 to the annular space 117 between the body and the inner wall 86 of the casing, this fluid flowing around the members 17 and the cutters 11, as well as discharging upon the shoulder E to clean cuttings from the apparatus and the drilling region and flushing the cuttings around the

exterior of the casing string A to the top of the bore. In the event the drilling apparatus is elevated from the bottom of the hole and the formation shoulder E, the tension spring 100 will maintain the mandrel 19*a* in a downward position within the body 12 of the tool, thereby retaining the members 17 and cutters 11 in their outward expanded position.

When the expansible rotary drill bit is to be removed from the well casing, a suitably overshot (not shown) is lowered on a sand line (not shown), the overshot being coupled to the mandrel head 120*a*. An upward pull is now taken on the mandrel 19*a*, overcoming the force of the spring 100 and elevating the mandrel within the body 12, which cannot move upwardly at this time due to the engagement of the shoulders 84 on the members 17 with the companion shoulders 83 at the upper ends of the slots 81. When the expander 34 is elevated above the surfaces 35 of the members 17, the retrieving flange 75 on the mandrel will engage the upper arms 76 of the members 17 and thereby swing the lower portions 17*a* of the members (and also cutters 11) inwardly, the outer surfaces 105 of the members 17 sliding along the inner wall of the casing A during elevation of the apparatus on the sand line through the well casing to the top of the bore hole. The drill bit apparatus C is removed from the casing string A and, if desired, another expansible cutter apparatus lowered therethrough to be latched to shoe portion 10.

WHAT I CLAIM IS:—

1. A retrievable drilling bit adapted to be lowered within, and coupled to, the lower portion of a string of pipe disposed in a well bore, said bit comprising a body movable longitudinally through the pipe, initially retracted cutter means mounted on said body for movement laterally outwardly of said body, means to engage a lower portion of the pipe so to locate the bit in the pipe so that said cutter means projects below the lower end of the pipe and means for expanding said cutter means laterally outwardly of the body for drilling a bore hole having a diameter greater than that of the outside diameter of the pipe, the cutter means, when expanded, being directly coupled to the pipe so that torque and downwardly longitudinal force applied to the pipe is transmitted to the cutter means.

2. A drilling bit according to claim 1, in which the cutter-expanding means is engageable with the cutter means for expanding the cutter means outwardly, said cutter-engaging means being movable longitudinally of the body thereby to expand the cutter means.

3. A drilling bit as claimed in claim 2, wherein said cutter-engaging means is movable longitudinally in one direction to expand the cutter means and there is a releasable latch means for preventing inadvertent movement of said cutter-engaging means in the opposite longitudinal direction after the cutter means has been expanded.

4. A drilling bit as claimed in claim 2 or 3, in which the cutter-expanding means is mechanically actuated.

5. A drilling bit as claimed in claim 2 or 3 in which the cutter-expanding means is hydraulically actuated.

6. A drilling bit as claimed in claim 2 or 3, wherein the cutter-expanding means is mechanically and hydraulically actuated.

7. A drilling bit according to any preceding claim in which the lower end of the string of pipe is slotted and the means to locate the bit in the pipe is so arranged that upon outward expansion of the cutter means the latter enters the slots thereby directly to couple the cutter means to the pipe.

8. A drilling bit as claimed in claim 7, in which said slots have thrust means to engage thrust means on the cutter means to transmit drilling weight from the slotted pipe directly to the cutter means.

9. A drilling bit according to claim 3 or any claim appendant thereto having means for releasing said latch means and for moving said cutter-engaging means in the opposite longitudinal direction for retraction of the cutter means.

10. A drilling bit as claimed in claim 9, in which the cutter-engaging means comprises a mandrel within the body and responsive to the pressure of fluid pumped down the pipe, said mandrel being movable downwardly relatively to the body by the hydraulic pressure thereby to expand the cutter means.

11. A drilling bit according to claim 10, in which the latch means acts between the mandrel and said body to prevent upward movement of the mandrel within said body.

12. A drilling bit according to claim 4 or 6 or any claim appendant thereto in which the cutter-expanding means is spring actuated.

13. A drilling bit as claimed in claim 12, as appendant to claim 10 or 11, wherein said spring acts between the body and the mandrel to urge the mandrel to expand the cutter means.

14. A drilling bit as claimed in claim 9, in which the cutter-engaging means comprises a mandrel within the body, the mandrel having a head for receiving a bit-retrieving device lowered into the pipe and a spring between the body and the mandrel for urging the mandrel to expand the cutter means, said device moving the mandrel against the spring to release the latch means, retract the cutter means and raise the body through the pipe.

15. A drilling bit according to claim 5 or any claim appendant thereto in which the cutter means is hydraulically actuated by liquid pumped down the pipe and the liquid is discharged in the region of the cutter means.

16. A drilling bit as claimed in claim 15

in which the liquid is directed into said body to act upon the cutter-expanding means and is discharged from said body to an annular space between the body and the pipe and is also discharged from the lower end of the body through an axial nozzle.

17. A drilling bit according to claim 16 wherein said annular space and the axial nozzle provide a restricted passage to the liquid such that there is a build up in pressure within the body acting on the cutter-expanding means.

18. A retrievable drilling bit substantially as hereinbefore described and as illustrated in Figures 1 to 7 or Figures 8 and 9 of the accompanying drawings.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

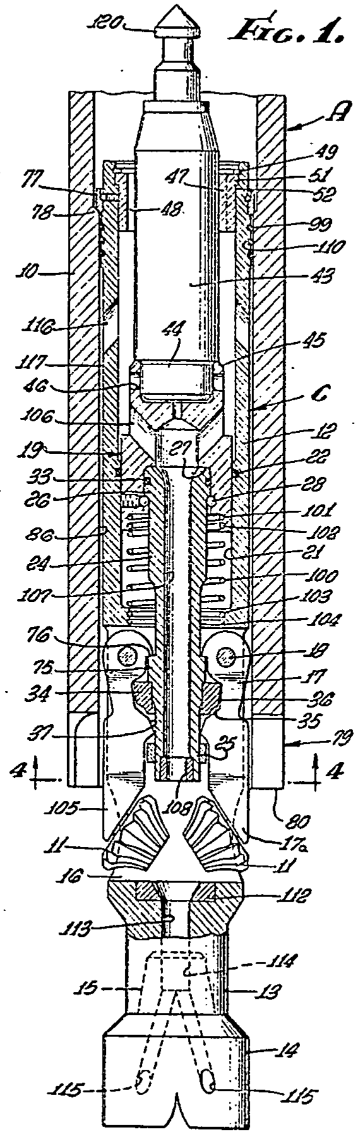


FIG. 1.

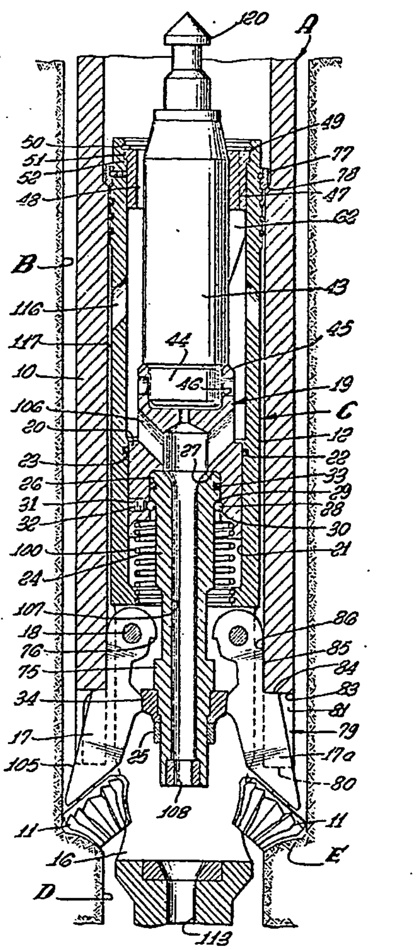
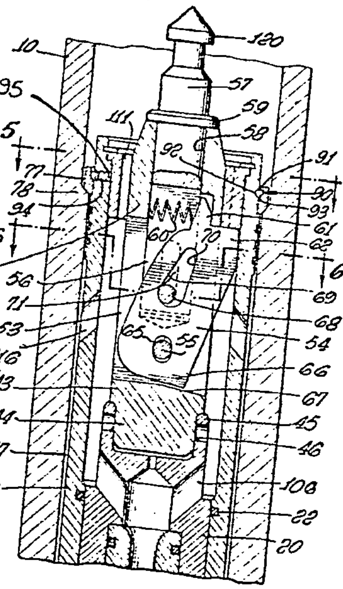


FIG. 2.

FIG. 3.



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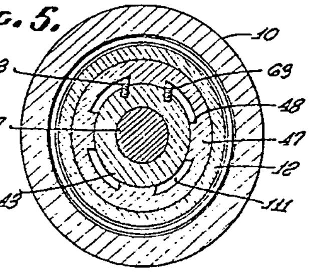

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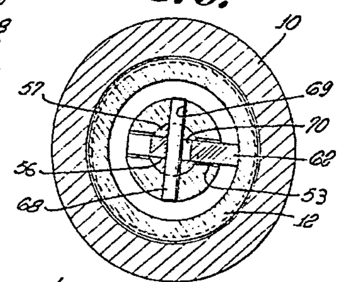


FIG. 7.

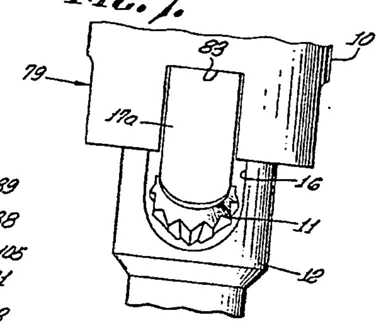
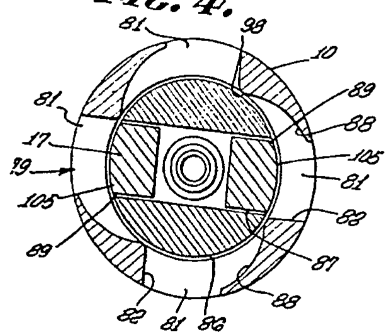


FIG. 4.



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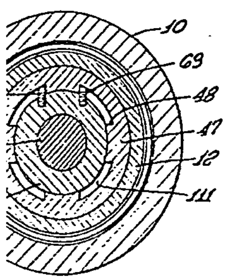

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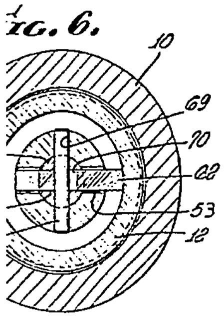


FIG. 7.

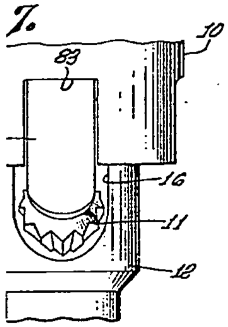


FIG. 8.

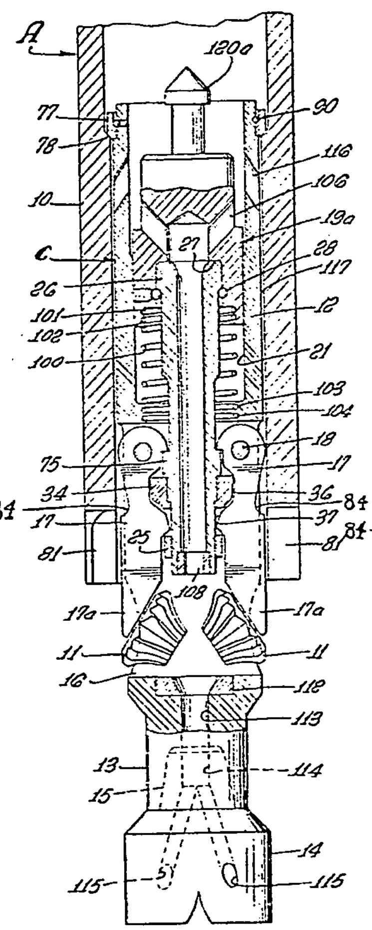
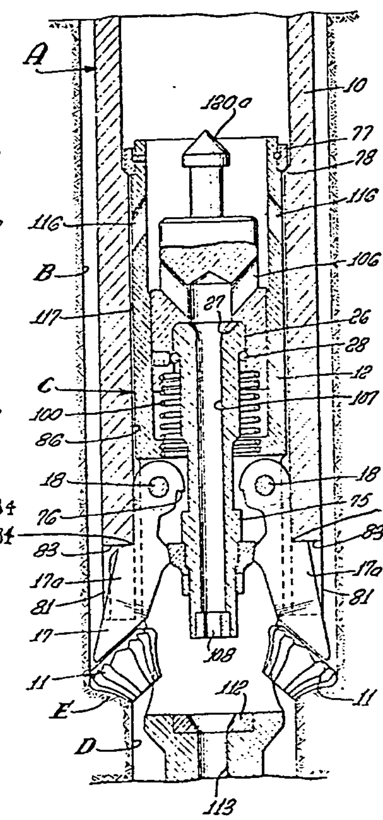


FIG. 9.



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Sheets 2 & 3

Fig. 3.

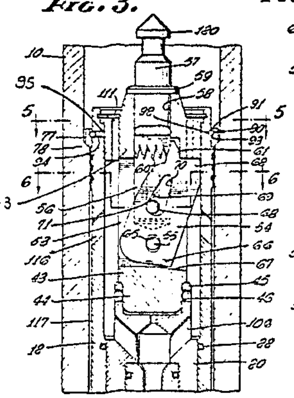

Fig. 5.

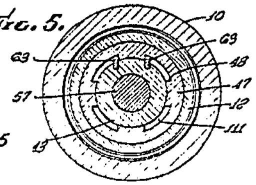

Fig. 6.

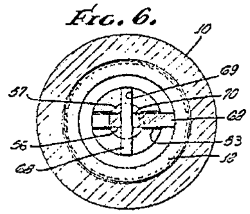

Fig. 7.

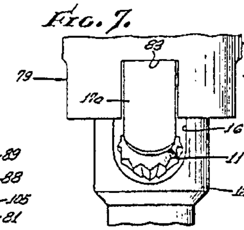

Fig. 4.

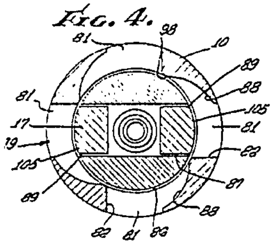

Fig. 8.

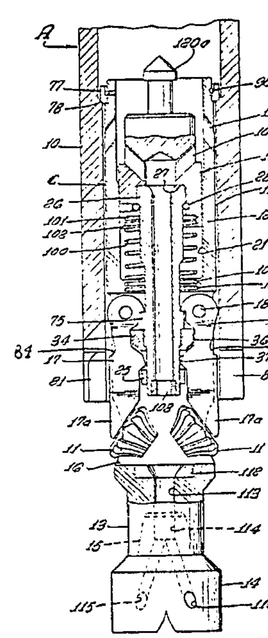

Fig. 9.